

533 Rec'd PCT/PTO 14 AUG 2001

FORM PTO-1390
REV. 5-93

US DEPARTMENT OF COMMERCE
PATENT AND TRADEMARK OFFICE

ATTORNEYS DOCKET NUMBER
P01,0271

**TRANSMITTAL LETTER TO THE UNITED STATES
DESIGNATED/ELECTED OFFICE (DO/EO/US)
CONCERNING A FILING UNDER 35 U.S.C. 371**

U.S. APPLICATION NO. (if known, see 37 CFR 1.5)

09/913451

INTERNATIONAL APPLICATION NO.

INTERNATIONAL FILING DATE

PRIORITY DATE CLAIMED

PCT/DE00/00463

18 February 2000

18 February 1999

TITLE OF INVENTION

CONFIGURABLE ADD-DROP MULTIPLEXING DEVICE AND OPTICAL WAVELENGTH DIVISION MULTIPLEX TRANSMISSION SYSTEM (Title Amended)

APPLICANT(S) FOR DO/EO/US

Detlef Stoll et al

Applicant herewith submits to the United States /Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☐ This express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay.
4. ☒ A proper Demand for International Preliminary Examination will be made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of International Application as filed (35 U.S.C. 371(c)(2))
 - a. ☒ is transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ has been transmitted by the International Bureau.
 - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US)
6. ☒ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. §371(c)(3))
 - a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
 - b. ☐ have been transmitted by the International Bureau.
 - c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
 - d. ☒ have not been made and will not be made.
8. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)). **Executed**
10. ☒ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11. to 16. below concern other document(s) or information included:

11. ☐ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98; **(PTO 1449, Prior Art, Search Report).**
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.
(SEE ATTACHED ENVELOPE)
13. ☒ A **FIRST** preliminary amendment.
☐ A **SECOND** or **SUBSEQUENT** preliminary amendment.
14. ☒ A substitute specification - **Marked up copy of Substitute Specification.**
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
 - a. ☒ Submission of Drawings - **Four sheets of drawings**
 - b. ☒ **EXPRESS MAIL #EL655301823US dated August 14, 2001.**

BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5):

Search Report has been prepared by the EPO or JPO \$860.00

International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) \$690.00

No international preliminary examination fee paid to USPTO (37 C.F.R. 1.482) but
international search fee paid to USPTO (37 C.F.R. 1.445(a)(2)) \$760.00Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search
fee (37 C.F.R. 1.445(a)(2)) paid to USPTO \$970.00International preliminary examination fee paid to USPTO (37 C.F.R. 1.482) and all claims
satisfied provisions of PCT Article 33(2)-(4) \$96.00**ENTER APPROPRIATE BASIC FEE AMOUNT =**

\$860.00

Surcharge of \$130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the
earliest claimed priority date (37 C.F.R. 1.492(e)).

\$ 0

Claims

Number Filed

Number
Extra

Rate

Total Claims

16

- 20 =

0

X \$ 18.00

\$ 0

Independent Claims

3

- 3 =

0

X \$ 80.00

\$0

Multiple Dependent Claims

\$270.00 +

\$

TOTAL OF ABOVE CALCULATIONS =

\$ 0

Reduction by 1/2 for filing by small entity, if applicable. Verified Small Entity statement must also be
filed (Note 37 C.F.R. 1.9, 1.27, 1.28)

\$

SUBTOTAL =

\$ 860.00

Processing fee of \$130.00 for furnishing the English translation later than ☐ 20 ☐ 30 months from
the earliest claimed priority date (37 CFR 1.492(f)).

\$

TOTAL NATIONAL FEE =

\$ 0

Fee for recording the enclosed assignment (37 C.F.R. 1.21(h). The assignment must be
accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). \$40.00 per property

+

TOTAL FEES ENCLOSED =

\$860.00

Amount to be
refunded

\$

charged

\$

a. ☒ A check in the amount of \$ **860.00** to cover the above fees is enclosed.b. ☐ Please charge my Deposit Account No. _____ in the amount of \$ _____ to cover the above fees. A duplicate
copy of this sheet is enclosed.c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment
to Deposit Account No. **501519**. A duplicate copy of this sheet is enclosed.NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be
filed and granted to restore the application to pending status.**SEND ALL CORRESPONDENCE TO:**Schiff Hardin & Waite
Patent Department
6600 Sears Tower
Chicago, Illinois 60606
CUSTOMER NO. 26574

SIGNATURE

Brett A. Valiquet

NAME

27,841

Registration Number

1

BOX PCT
IN THE UNITED STATES ELECTED OFFICE
OF THE UNITED STATES PATENT AND TRADEMARK OFFICE
UNDER THE PATENT COOPERATION TREATY-CHAPTER II

5

PRELIMINARY AMENDMENT

APPLICANT: Detlef STOLL et al

DOCKET NO: P01,0271

SERIAL NO:

GROUP ART UNIT:

EXAMINER:

10

INTERNATIONAL APPLICATION NO: PCT/DE00/00463

INTERNATIONAL FILING DATE: 18 February 2000

INVENTION: "CONFIGURABLE ADD-DROP MULTIPLEXING DEVICE
AND OPTICAL WAVELENGTH DIVISION MULTIPLEX
TRANSMISSION SYSTEM" (Title Amended)

15

Assistant Commissioner for Patents,
Washington, D.C. 20231

Sir:

20

As a Preliminary Amendment for entry into the
National Stage for the above-identified PCT application,
the following is submitted:

IN THE ABSTRACT:

Please add the following Abstract:

--An add-drop multiplexer has a group filter that
divides an incoming WDM signal into several channel
groups of corresponding adjacent WDM channels. A

09/913451 PCT/PTO

5

IN THE SPECIFICATION:

10

IN THE CLAIMS:

Please cancel claims 1-15 without prejudice.

Please substitute new claims 16-31 as follows:

15

20

a plurality of exchangeable modules each of which connect to a respective channel group for connecting through and branching off channels;

25

the first module type being for manual reconfiguration of connected-through and add-drop

channels with which longer-term connections of the channels of a channel group are realized;

the second module type being for remote configuration of channels to be connected through and add-drop channels of one of the channel groups with which short-term connections of the channels of the one channel group are realized;

the third module type being for closed connecting-through of a channel group; and
a combination filter to which reconfigured channel groups are fed and which forms an outgoing WDM signal.

17. The add-drop multiplexing device of claim 16 wherein the first module type comprises substantially a WDM demultiplexer, a manually configurable switching unit, and a WDM multiplexer.

18. The add-drop multiplexing device of claim 16 wherein the second module type comprises a WDM demultiplexer, a remote-configurable switching unit, and a WDM multiplexer.

19. The add-drop multiplexing device of claim 16 wherein the second module type comprises an add-drop-continue device with a series connection of at least one circulator, a tunable filter, and a coupling-in device.

20. The add-drop multiplexing device of claim 19 wherein the transmission loss of the tunable filter is adjustable.

21. The add-drop multiplexing device of claim 20 wherein the transmission loss of the tunable filter is thermally adjustable.

22. The add-drop multiplexing device of claim 16 wherein the third module type comprises an optical connecting cable.

23. The add-drop multiplexing device of claim 16 wherein there is provided a fourth module type which makes possible a remote configuration of drop-continue channels.

24. The add-drop multiplexing device of claim 23 wherein the fourth module type has a coupling device for coupling out at least part of the incoming WDM signal and a circulator and also at least one tunable filter.

25. The add-drop multiplexing device of claim 23 wherein the fourth module type has a coupling device for coupling out at least part of the incoming WDM signal, and at least one filter arrangement acting as a WDM demultiplexer for separating the coupled-out WDM signal into a plurality of channels of different wavelength.

26. The add-drop multiplexing device of claim 19 wherein narrow-band series-connected Bragg channel filters are provided which are tuned with regard to resonant wavelength, a stop band of which is so narrow that a filter tuned to a wavelength lying between the

channels significantly does not influence a function of adjacent channels.

27. The add-drop multiplexing device of claim 26 wherein the series connection of the tunable filters is terminated by an optical absorber into which non-reflected WDM signals are directed.

28. The add-drop multiplexing device of claim 24 wherein for coupling-out of a plurality of channels, a WDM demultiplexer is additionally provided designated at least for a number of the channels which corresponds to a number of the tunable filters.

29. The add-drop multiplexing device as claimed in claim 16 wherein the channels of at least one of the channel groups are adjacent in terms of frequency.

30. A wavelength division multiplex transmission system, comprising:

a plurality of add-drop multiplexing devices connected to one another via optical waveguides; and

each of the add-drop multiplexing devices comprising

a group filter which divides an incoming WDM signal into a plurality of channel groups with channels of different wavelengths,

a plurality of exchangeable modules each of which connects to a respective channel group for connecting through and branching off channels,

the exchangeable modules comprising at least one of first, second, and third module types, the first module type being for manual reconfiguration of connected-through and add-drop channels with which longer-term connections of the channels of a channel group are realized, the second module type being for remote configuration of channels to be connected through and add-drop channels of one of the channel groups with which short-term connections of the channels of the one channel group are realized, the third module type being for closed connecting-through of a channel group, and a combination filter to which reconfigured channel groups are fed and which forms an outgoing WDM signal.

31. A configurable add-drop multiplexing device for an optical wavelength division multiplex transmission system, comprising:

a group unit which divides an incoming WDM signal into a plurality of channel groups;

a plurality of exchangeable modules each of which connect to a respective channel group for connecting through and branching off channels;

the exchangeable modules comprising at least one of first, second, and third module types;

the first module type being for manual reconfiguration of connected-through and add-drop

channels with which longer-term connections of the channels of a channel group are realized;

the second module type being for remote configuration of channels to be connected through and add-drop channels of one of the channel groups with which short-term connections of the channels of the one channel group are realized;

the third module type being for closed connecting-through of a channel group; and
a combination unit to which reconfigured channel groups are fed and which forms an outgoing WDM signal.

REMARKS

An Abstract has been added in accordance with U. S. practice.


The specification has been amended for improved readability and clarity and in accordance with U. S. practice.

New claims are presented in accordance with U. S. practice. The new claims are not narrower than the original claims and the new claims are not presented for

patentability reasons so that the *Festo* decision does not apply.

Respectfully submitted,

5


Brett A. Valiquet (Reg. No. 27,841)

10

Schiff Hardin & Waite
Patent Department
6600 Sears Tower
Chicago, Illinois 60606
Telephone: 312-258-5786
ATTORNEY FOR APPLICANT

15

CUSTOMER NUMBER 26574

RECEIVED
FEB 10 1994

03-08-2001
1999P01234WO

4/PATS

533 Rec'd PCT/PTO 14 AUG 2001

PCT/DE00/00463

09/913451

- 1 -

Description

Configurable add-drop multiplexing device and optical wavelength division multiplex transmission system

5

The invention relates to a configurable add-drop multiplexing devices and an optical wavelength division multiplex (WDM) transmission system realized with these devices.

10

In purely optical WDM networks, transmission channels with different wavelengths are used for establishing data connections. At the request of customers, connections between any desired connecting points are to be made available by the network operator. To establish these connections, until now electronically operating cross-connectors/connecting-through devices were used. The same principle can also be used in principle for purely optically operating networks. However, here the use of remote-configurable optical switching devices is problematical and very cost-intensive. Such devices are known for example from DE 19 94 302 A1.

15

20

25

US 5,748,350 discloses optical multiplexers/demultiplexers which are realized with the aid of filters and circulators and combine individual optical channels to form a WDM signal or divide a WDM signal into individual optical channels.

30

It is therefore an object of the invention to provide a configurable add-drop multiplexing device and a WDM transmission system which can be realized with lower expenditure.

35

This object is achieved by an add-drop multiplexing

AMENDED SHEET

09/913451-034401

- 1a -

device according to patent claim 1. An associated transmission system is specified in an independent claim. Advantageous developments are specified in the subclaims.

5

In the invention, a modular design is used, allowing different module types to be used according to requirements. Generally, only a small number of the switched connections have to be frequently reconfigured, while generally the majority of the connections are static and never have to be reconfigured, or only extremely rarely. There is a correspondingly great cost advantage.

10

T 03 08 2001 P 01 23 4 WO

It is firstly advantageous for the WDM signal to be divided into a plurality of channel groups, at least one of which are divided by a WDM demultiplexer into individual optical channels, which in principle can be individually branched off or connected through. One of these channel groups is assigned for example "statically" interconnected channels for long-term connection, which are fed to a module of a technically simple configuration, while another channel group contains channels serving as short-term connections, which are constantly newly interconnected, which takes place in another module type with correspondingly more complex switching devices.

Use of the invention in ring networks, in which a considerable number of the channels are merely through-connected, is particularly advantageous. Here, the corresponding module then only comprises one optical connecting line.

In addition to the use of modules with optical switching matrices for realizing add-drop functions, a combination of circulators and tunable filters may also be used as an add-drop unit.

Particularly advantageous is the use of tunable controllable filters, the transmission loss and reflection loss of which for example are thermally controllable and, as a result, make a reconfiguration possible without disturbing operation on the through-connected channels.

In addition, drop&continue channels which can be remote-configured with the aid of a further module type are advantageously used according to the invention for realizing broadcast functionalities.

- 2a -

Exemplary embodiments of the invention are explained in more detail with reference to figures,

in which:

FIG. 1 is a perspective view of a device according to the invention.

- 3 -

figure 1 shows an add-drop multiplexing device for static and remote-configurable connections,
figure 2 shows a frequency diagram of an optical WDM signal,
5 figure 3 shows a ring network and
figure 4 shows a variant of the add-drop multiplexing device.
figure 5 shows a variant of a drop&continue module.
figure 6 shows a further variant of a drop&continue
10 module.
figure 7 shows a simplified embodiment of a drop&continue module.

Represented in figure 1 is an add-drop multiplexing
15 device (often referred to for short as an add-drop multiplexer or a network node, cross-connector or through-connecting device) NK1. An incoming optical WDM signal WMS1 is initially fed to a group filter 1. This divides the signal WMS1 into four different
20 channel groups G1 to G4 in a way corresponding to figure 2. The static connections are assigned to the channel groups G1 to G3, while all the short-term connections are assigned to the fourth channel group G4. Each of these channel groups is respectively
25 assigned a module MM1 to MM3 and MF4, to allow specific channels to be branched off and inserted and other channels to be connected through. In this case, it is expedient for reasons of expenditure and required in the case of certain embodiments to assign channels
30 which are adjacent in terms of frequency to one channel group. However, a functional connection-oriented assignment is also possible.

In the case of the module MM1, only two add-drop
35 terminals 24 and 25 are denoted for reasons of overall clarity. The channels of this module which are to be sent are combined in a WDM multiplexer 13. The module has a manual patch panel 6, with which any desired

- 3a -

connections can be manually made with the aid of what are known as "patch courts". The modules M2 and M3 likewise contain in each case a WDM demultiplexer 3 and 4, respectively, a manual patch panel 7 and 8, respectively, and a WDM multiplexer 14 and 15, respectively. Only the fourth

T 0 4 9 7 5 2 " P C T / D E 0 0 / 0 0 4 6 3

module has between its WDM demultiplexer 5 and its WDM multiplexer 16 a remote-configurable patch panel 9 with a plurality of switching matrices 10 with four terminals in each case. Each of these switching matrices allows a "channel" separated by the WDM demultiplexer 15 to be connected through or branched off and inserted into a corresponding "channel". The drop terminal of one of two switching matrices represented is denoted here by 11 and the add terminals is denoted by 12. The channel groups N1 to N4 reconfigured with the aid of the WDM multiplexers 13 to 16 are combined by a combination filter 17 and sent.

Each add-drop multiplexer can be adapted to requirements by exchanging modules. If, for example, a higher proportion of remote-configurable connections is desired, the module MM3 can be replaced for example by a type of the module MF4. For reasons of overall clarity, only for one direction of transmission and only the elements essential for the invention have been represented. In the case of bidirectional connections, an identical arrangement is provided for the opposite direction.

In optical rings in which these network elements are used, it is possible both for genuine ring traffic to be conducted, as known from synchronous networks, and also for what is known as HUB traffic to be carried out in a way corresponding to figure 3, requiring various add-drop multiplexers which are connected in the form of a ring via optical waveguides 28 and 29. A first add-drop multiplexing device NK1 serves as a central node (master node), which logically distributes the traffic in a double-star shape to the other add-drop multiplexers. The master node must correspondingly have an add-drop capacity of 100%, as is represented in figure 1, with 75% static traffic and 25% remote-configurable traffic (for example in a way

- 4a -

corresponding to figure 1). The other multiplexers/network nodes NK2, NK3 and NK4 require only a relatively small add-drop capacity, of which in turn only a

PCT/DE00/00463

part must be remote-configurable. A major part of the traffic, concentrated on certain channel groups, is connected through.

5 An add-drop multiplexing device possible for the network nodes NK2 to NK4 is represented in figure 4. It contains two modules MD21 and MD22, which comprise in each case an optical connecting line 23. A further module MM22 is in turn provided for static connections
10 and the module MF24 is provided for remote-configurable connections. This module contains at least one circulator 18 and a tunable filter 19, with the aid of which individual wavelengths, and consequently individual channels, can be branched off. With the aid
15 of further circulators 20 and tunable filters 21, further channels (or else groups of a plurality of channels) can be branched off at drop outputs 26. The corresponding channels (with new data) are inserted via add inputs 27 and a coupler 22.

20 It is particularly advantageous if the module MF24 is designed in such a way that, during a reconfiguration, i.e. during detuning of the filters 19 and 21, the other connected-through channels are not disturbed.
25 This may take place by bridging the filters or by thermally influencing the filters, by which the filter properties are largely reduced. Corresponding filters and corresponding add-drop-continue modules are described in German Patent Application DE 19846674.9.
30 The module MM22, the group filter and the combination filter coincide with the network node NK1.

Represented in figure 5 is a variant of a drop&continue module MF25 for remote-configurable
35 drop&continue channels, which has a coupler 22, a circulator 30, a tunable filter 31 and also an absorber 35. The continue functionality of the drop&continue module MF25 is realized with the aid

0049752-0440

of an optical connecting line 23, which

WO 00/49752 - PCT/DE00/00463

connects the input e of the drop&continue module MF25 via the coupler 22 to the output a of the drop&continue module MF25 and via which, for example, all the short-term connections of the fourth channel group G4 are transmitted. The drop functionality of the drop&continue module MF25 is realized in particular with the aid of the coupler 22, the tunable filter 31 and the circulator 30, a part of the optical WDM signal representing the fourth channel group G4 being coupled out by the coupler 22 and transmitted via a further optical connecting line 36 to the circulator 30. Consequently, a single channel, for example channel K25, of the channel group G4 can be branched off via the tunable filter 31. The part of the coupled-out optical WDM signal not separated by the tunable filter 31 and representing the fourth channel group G4 is passed on to the optical absorber 35, which is provided for the disposal of these non-reflected WDM channels K26 to K32. In addition, the drop&continue module MF25 may optionally be extended with the aid of an add terminal 12, which is led to the coupler 22, to form an add-drop&continue module - indicated in figure 5 by an add terminal line 12 depicted by dashed lines. In this case, only WDM signals of a wavelength outside the wavelength range which can be extracted by the tunable filter 31 can be fed in or "added".

Represented in figure 6 is an extended module MF26 of the drop&continue module MF25 represented in figure 5, for the branching off of a plurality of channels K25 to K32 of the fourth channel group G4. This extended module MF26 has for this purpose, for example, a further tunable filter 33 and a WDM demultiplexer 34, intended for the separation of the backscattered channels K25 to K32. With the aid of this extended module MF26, the channel selectivity of the drop&continue module MF26 can be advantageously

- 6a -

increased, which is advantageous when there are a large number of WDM channels.

- 7 -

- Represented in figure 7 is a simplified embodiment of the drop&continue functionality in a further module MF27, in which a part of the optical WDM signal representing the fourth channel group G4 is led
- 5 directly to a WDM multiplexer 34 with the aid of a coupler 22, which is connected into the optical connecting line 23, via an optical connecting line 36. With the aid of the WDM multiplexer 36, the respective WDM channel K25 to K32 is subsequently branched off and
- 10 led to the respective drop terminal 11. An embodiment of a drop&continue module of this type can be advantageously used in particular in the case of a low channel density per channel group G1 to G4.
- 15 It goes without saying that a plurality of the add-drop multiplexers described above may also be connected in series in a network terminal.

Patent claims

1. A configurable add-drop multiplexing device for an optical wavelength division multiplex transmission system, characterized in that in each of the add-drop multiplexing devices there is provided a group filter (1), which divides an incoming WDM signal (WMS1) into a plurality of channel groups (G1-G4) with channels (K1-K32) of different wavelengths, in that there is provided a plurality of exchangeable modules (M1-M4) for connecting through and branching off channels, to which in each case a channel groups (G1-G4) is fed, in that different module types (MM, MD, MF) are used as and when required, in that there is provided a first module type (MM) for the manual reconfiguration of connected-through and add-drop channels (K1 - K8), with which long-term connections of the channels (K9-K16) of a channel group (G1, G2, G3; G4) are realized, and/or there is provided a second module type (MF) for the remote configuration of channels to be connected through and add-drop channels (K25 - K32) of in each case a further channel group (G4), with which short-term connections of the channels (K25-K32) of this further channel group (G4) are realized, and/or in that there is provided a third module type (MD) for the closed connecting-through of in each case a channel group (G1, G3) and in that there is provided a combination filter (17), to which the possibly reconfigured channel groups (N1-N4), which are combined to form an outgoing WDM signal (WMS2), are fed.
2. The add-drop multiplexing device as claimed in claim 1, characterized

in that the first module type (MM) contains essentially a WDM demultiplexer (2), a manually configurable switching unit (6) and a WDM multiplexer (13).

5

3. The add-drop multiplexing device as claimed in claim 1 or 3, characterized in that the second module type (MF) contains a WDM demultiplexer (5), a remote-configurable switching unit (9) and a WDM multiplexer (16).

10

4. The add-drop multiplexing device as claimed in claim 1 or 3, characterized in that the second module type (MF) contains an add-drop-continue device with the series connection of at least one circulator (18), a tunable filter (19) and also a coupling-in device (20).

15

5. The add-drop multiplexing device as claimed in claim 4, characterized in that the transmission loss of the filter (19) is adjustable.

20

6. The add-drop multiplexing device as claimed in claim 5, characterized in that the transmission loss of the filter (19) is thermally adjustable.

25

7. The add-drop multiplexing device as claimed in one of the preceding claims, characterized in that the third module type (MD) is realized by an optical connecting cable (23).

30

8. The add-drop multiplexing device as claimed in claim 1, characterized in that there is provided a fourth module type (MF25, MF26, MF27), which makes possible a remote configuration of drop-continue channels.

35

9. The add-drop multiplexing device as claimed in claim 8, characterized in that the fourth module type (MF25, MF26, MF27) has a coupling device (22) for coupling out at least part of the incoming WDM signal and a circulator (30) and also at least one tunable filter (32, 33).
10. The add-drop multiplexing device as claimed in claim 8, characterized in that the fourth module type has a coupling device (22), for coupling out at least part of the incoming WDM signal, and at least one filter arrangement acting as a WDM demultiplexer (34), for separating the coupled-out WDM signal into a plurality of channels (K25 - K32) of different wavelength.
11. The add-drop multiplexing device as claimed in claim 4 or 9, characterized in that, provided as tunable filters (19, 32, 33) are narrow-band, series-connected Bragg channel filters which can be tuned with regard to the resonant wavelength and the stop band of which is so narrow that a filter (19, 32, 33) tuned to a wavelength lying between the channels (k25 - K32) does not influence the function of the adjacent channels (K25 - K32), at least not significantly.
12. The add-drop multiplexing device as claimed in claim 11, characterized in that the series connection of the tunable filters (19, 32, 33) is terminated by an optical absorber (35), into which non-reflected WDM signals are directed.
13. The add-drop multiplexing device as claimed in claim 9, characterized in that, for the coupling-out of a plurality of channels (K25 - K32), a WDM

demultiplexer (34) is additionally provided, designed at least for the number of channels (K25 - K32) which corresponds to the number of tunable filters (19, 32, 33).

5

14. The add-drop multiplexing device as claimed in one of the preceding claims, characterized in that the channels (K1 - K8) of a channel group (G1) are adjacent in terms of frequency.

10

15. A wavelength division multiplex transmission system with a plurality of add-drop multiplexing devices (NK1 - NK4) as claimed in one of the preceding claims connected to one another via optical waveguides (28, 29).

15

4/PATS

09/913451

1

SPECIFICATION**TITLE**

5 **“CONFIGURABLE ADD-DROP MULTIPLEXING DEVICE AND
OPTICAL WAVELENGTH DIVISION MULTIPLEX TRANSMISSION
SYSTEM”**

BACKGROUND OF THE INVENTION

10 The invention relates to configurable add-drop multiplexing devices and an optical wavelength division multiplex (WDM) transmission system realized with these devices.

15 In purely optical WDM networks, transmission channels with different wavelengths are used for establishing data connections. At the request of customers, connections between any desired connecting points are to be made available by the network operator. To establish these connections, until now electronically operating cross-connectors/connecting-through devices were used. The same principle can also be used in principle for purely optically operating networks. However, here the use of remote-configurable optical switching devices is problematical and very cost-intensive.

20 Such devices are known for example from DE 19 94 302 A1.

US 5,748,350 discloses optical multiplexers/ demultiplexers which are realized with the aid of filters and circulators and combine individual optical channels to form a WDM signal or divide a WDM signal into individual optical channels.

25 **SUMMARY OF THE INVENTION**

It is therefore an object of the invention to provide a configurable add-drop multiplexing device and a WDM transmission system which can be realized with a lower expenditure.

30

This object is achieved by an add-drop multiplexing device for an optical wavelength division multiplex transmission system wherein a group filter is provided which divides an incoming WDM signal into a plurality of channel groups with channels of different wavelengths. A plurality of exchangeable modules are provided to each of which a respective channel group is fed for connecting through and branching off channels. The exchangeable modules are one of at least first, second, and third module types. The first module type is for manual reconfiguration of connected-through and add-drop channels with which long-term connections of the channels of the channel group are realized. The second module type is for remote configuration of channels to be connected through and add-drop channels of a further channel group with which short-term connections of the channels of the further channel group are realized. The third module type is for closed connecting-through of a channel group. A combination filter is provided to which reconfigured channel groups are fed and which combines the reconfigured channel groups to form an outgoing WDM signal. An associated wavelength division multiplex transmission system is also provided comprising a plurality of the add-drop multiplexing devices described above and which are connected to one another via optical waveguides.

In the invention, a modular design is used, allowing different module types to be used according to requirements. Generally, only a small number of the switched connections have to be frequently reconfigured, while generally the majority of the connections are static and never have to be reconfigured, or only extremely rarely. There is a correspondingly great cost advantage.

It is first advantageous for the WDM signal to be divided into a plurality of channel groups, at least one of which are divided by a WDM demultiplexer into individual optical channels, which in principle can be individually branched off or connected through. One of these channel groups is assigned for example "statically", to interconnected channels for long-term connection, which are fed to a module of a technically simple configuration, while another channel group contains channels serving as short-term connections, which are constantly newly interconnected, which takes place in another module type with correspondingly more complex switching devices.

Use of the invention in ring networks, in which a considerable number of the channels are merely through-connected, is particularly advantageous. Here, the corresponding module then only comprises one optical connecting line.

In addition to the use of modules with optical switching matrices for realizing
5 add-drop functions, a combination of circulators and tunable filters may also be used as an add-drop unit.

Particularly advantageous is the use of tunable controllable filters, the transmission loss and reflection loss of which for example are thermally controllable and, as a result, make a reconfiguration possible without disturbing operation on the through-
10 connected channels.

In addition, drop&continue channels which can be remotely configured with the aid of a further module type are advantageously used according to the invention for realizing broadcast functionalities.

Exemplary embodiments of the invention are explained in more detail with
15 reference to the drawing figures.

BRIEF DESCRIPTION OF THE DRAWING

Figure 1 shows an add-drop multiplexing device for static and remote-configurable connections;

20 Figure 2 shows a frequency diagram of an optical WDM signal;

Figure 3 shows a ring network;

Figure 4 shows a variation of the add-drop multiplexing device;

Figure 5 shows a variation of a drop&continue module;

Figure 6 shows a further variation of a drop&continue module; and

25 Figure 7 shows a simplified embodiment of a drop&continue module.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the preferred embodiment illustrated in the drawings and
30 specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alternations and further modifications in the illustrated device, and such further applications of the

principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

Represented in figure 1 is an add-drop multiplexing device (often referred to for short as an add-drop multiplexer or a network node, cross-connector or through-connecting device) NK1. An incoming optical WDM signal WMS1 is initially fed to a group filter 1. This divides the signal WMS1 into four different channel groups G1 to G4 in a way corresponding to figure 2. The static connections are assigned to the channel groups G1 to G3, while all the short-term connections are assigned to the fourth channel group G4. Each of these channel groups is respectively assigned a module MM1 to MM3 and MF4, to allow specific channels to be branched off and inserted and other channels to be connected through. In this case, it is expedient for reasons of expenditure and is required in the case of certain embodiments to assign channels which are adjacent in terms of frequency to one channel group. However, a functional connection-oriented assignment is also possible.

In the case of the module MM1, only two add-drop terminals 24 and 25 are denoted for reasons of overall clarity. The channels of this module which are to be sent are combined in a WDM multiplexer 13. The module has a manual patch panel 6, with which any desired connections can be manually made with the aid of what are known as "patch cords". The modules M2 and M3 likewise contain in each case a WDM demultiplexer 3 and 4, respectively, a manual patch panel 7 and 8, respectively, and a WDM multiplexer 14 and 15, respectively. Only the fourth module has between its WDM demultiplexer 5 and its WDM multiplexer 16 a remote-configurable patch panel 9 with a plurality of switching matrices 10 with four terminals in each case. Each of these switching matrices allows a "channel" separated by the WDM demultiplexer 15 to be connected through or branched off and inserted into a corresponding "channel". The drop terminal of one of two switching matrices represented is denoted here by 11 and the add terminal is denoted by 12. The channel groups N1 to N4 reconfigured with the aid of the WDM multiplexers 13 to 16 are combined by a combination filter 17 and sent.

Each add-drop multiplexer can be adapted to requirements by exchanging modules. If, for example, a higher proportion of remote-configurable connections is desired, the module MM3 can be replaced for example by a type of the module MF4. For reasons of overall clarity, only for one direction of transmission and only the elements

essential for the invention have been represented. In the case of bidirectional connections, an identical arrangement is provided for the opposite direction.

In optical rings in which these network elements are used, it is possible both for genuine ring traffic to be conducted, as known from synchronous networks, and also for what is known as HUB traffic to be carried out in a way corresponding to figure 3, requiring various add-drop multiplexers which are connected in the form of a ring via optical waveguides 28 and 29. A first add-drop multiplexing device NK1 serves as a central node (master node), which logically distributes the traffic in a double-star shape to the other add-drop multiplexers. The master node must correspondingly have an add-drop capacity of 100%, as is represented in figure 1, with 75% static traffic and 25% remote-configurable traffic (for example in a way corresponding to figure 1). The other multiplexers/network nodes NK2, NK3 and NK4 require only a relatively small add-drop capacity, of which in turn only a part must be remote-configurable. A major part of the traffic, concentrated on certain channel groups, is connected through.

An add-drop multiplexing device possible for the network nodes NK2 to NK4 is represented in figure 4. It contains two modules MD21 and MD22, which comprise in each case an optical connecting line 23. A further module MM22 is in turn provided for static connections and the module MF24 is provided for remote-configurable connections. This module contains at least one circulator 18 and a tunable filter 19, with the aid of which individual wavelengths, and consequently individual channels, can be branched off. With the aid of further circulators 20 and tunable filters 21, further channels (or else groups of a plurality of channels) can be branched off at drop outputs 26. The corresponding channels (with new data) are inserted via add inputs 27 and a coupler 22.

It is particularly advantageous if the module MF24 is designed in such a way that, during a reconfiguration, i.e. during detuning of the filters 19 and 21, the other connected-through channels are not disturbed. This may take place by bridging the filters or by thermally influencing the filters, by which the filter properties are largely reduced. Corresponding filters and corresponding add-drop-continue modules are described in German Patent Application DE 19846674.9. The module MM22, the group filter and the combination filter coincide with the network node NK1.

Represented in Figure 5 is a variation of a drop&continue module MF25 for

remote-configurable drop&continue channels, which has a coupler 22, a circulator 30, a tunable filter 31 and also an absorber 35. The continue functionality of the drop&continue module MF25 is realized with the aid of an optical connecting line 23, which connects the input e of the drop&continue module MF25 via the coupler 22 to the output a of the drop&continue module MF25 and via which, for example, all the short-term connections of the fourth channel group G4 are transmitted. The drop functionality of the drop&continue module MF25 is realized in particular with the aid of the coupler 22, the tunable filter 31 and the circulator 30, a part of the optical WDM signal representing the fourth channel group G4 being coupled out by the coupler 22 and transmitted via a further optical connecting line 36 to the circulator 30. Consequently, a single channel, for example channel K25, of the channel group G4 can be branched off via the tunable filter 31. The part of the coupled-out optical WDM signal not separated by the tunable filter 31 and representing the fourth channel group G4 is passed on to the optical absorber 35, which is provided for the disposal of these non-reflected WDM channels K26 to K32. In addition, the drop&continue module MF25 may optionally be extended with the aid of an add terminal 12, which is led to the coupler 22, to form an add-drop&continue module - indicated in figure 5 by an add terminal line 12 depicted by dashed lines. In this case, only WDM signals of a wavelength outside the wavelength range which can be extracted by the tunable filter 31 can be fed in or "added".

Represented in Figure 6 is an extended module MF26 of the drop&continue module MF25 represented in figure 5, for the branching off of a plurality of channels K25 to K32 of the fourth channel group G4. This extended module MF26 has for this purpose, for example, a further tunable filter 33 and a WDM demultiplexer 34, intended for the separation of the backscattered channels K25 to K32. With the aid of this extended module MF26, the channel selectivity of the drop&continue module MF26 can be advantageously increased, which is advantageous when there are a large number of WDM channels.

Represented in figure 7 is a simplified embodiment of the drop&continue functionality in a further module MF27, in which a part of the optical WDM signal representing the fourth channel group G4 is led directly to a WDM multiplexer 34 with the aid of a coupler 22, which is connected into the optical connecting line 23, via an optical connecting line 36. With the aid of the WDM multiplexer 36, the respective

WDM channel K25 to K32 is subsequently branched off and led to the respective drop terminal 11. An embodiment of a drop&continue module of this type can be advantageously used in particular in the case of a low channel density per channel group G1 to G4.

- 5 It goes without saying that a plurality of the add-drop multiplexers described above may also be connected in series in a network terminal.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and
10 described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

1/4

FIG 1

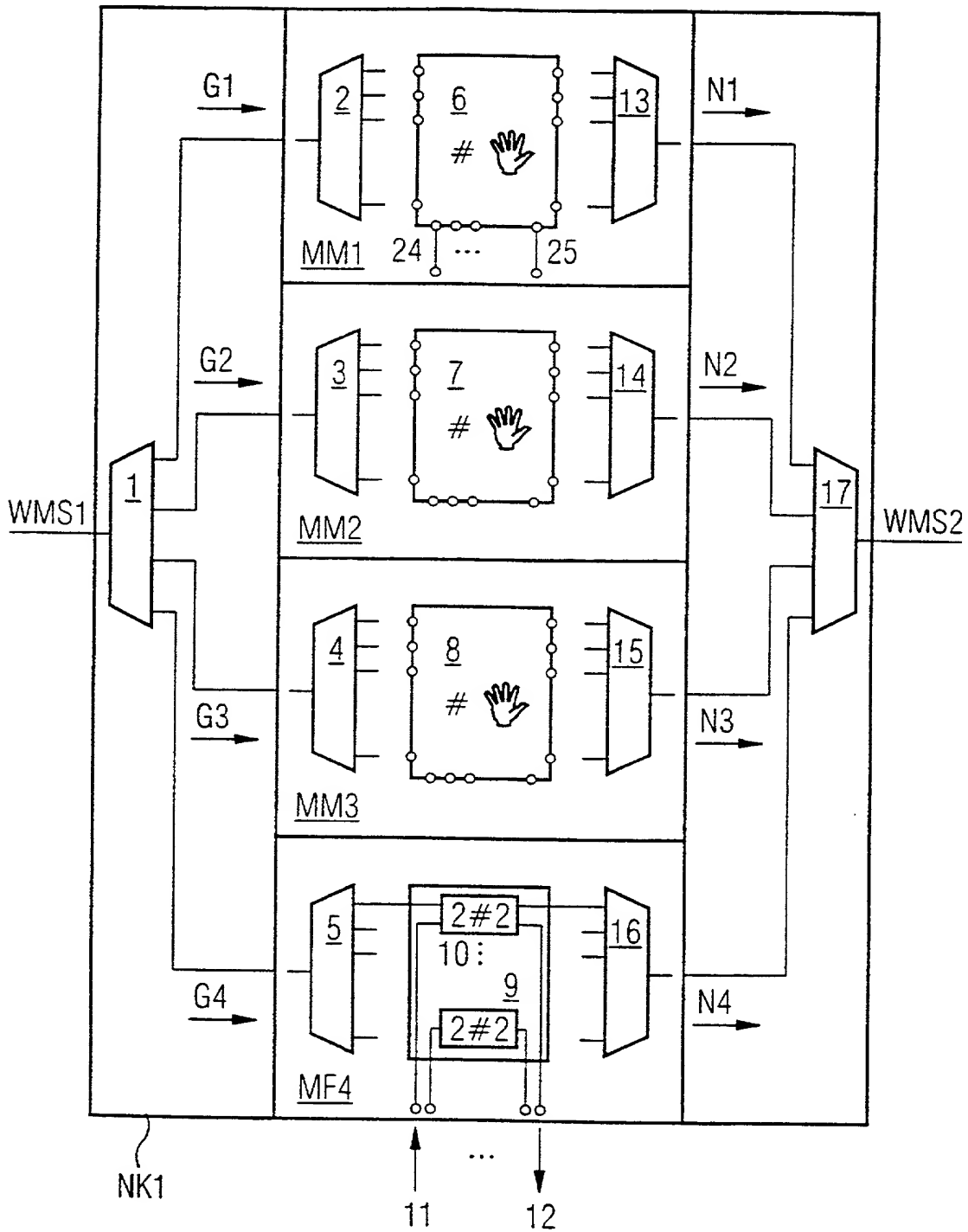


FIG 2

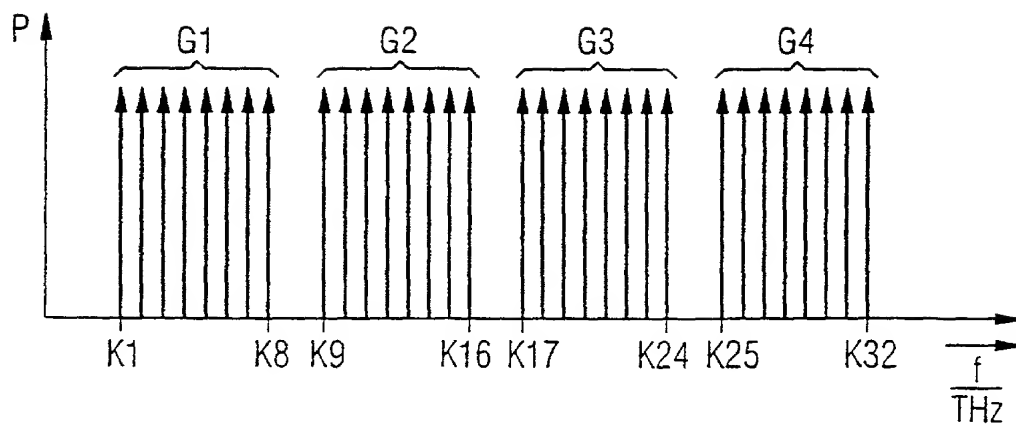
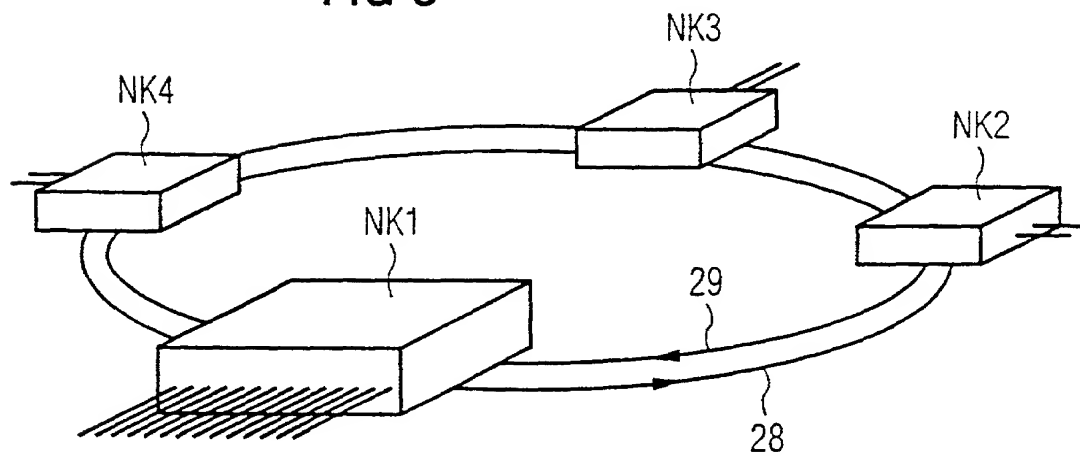
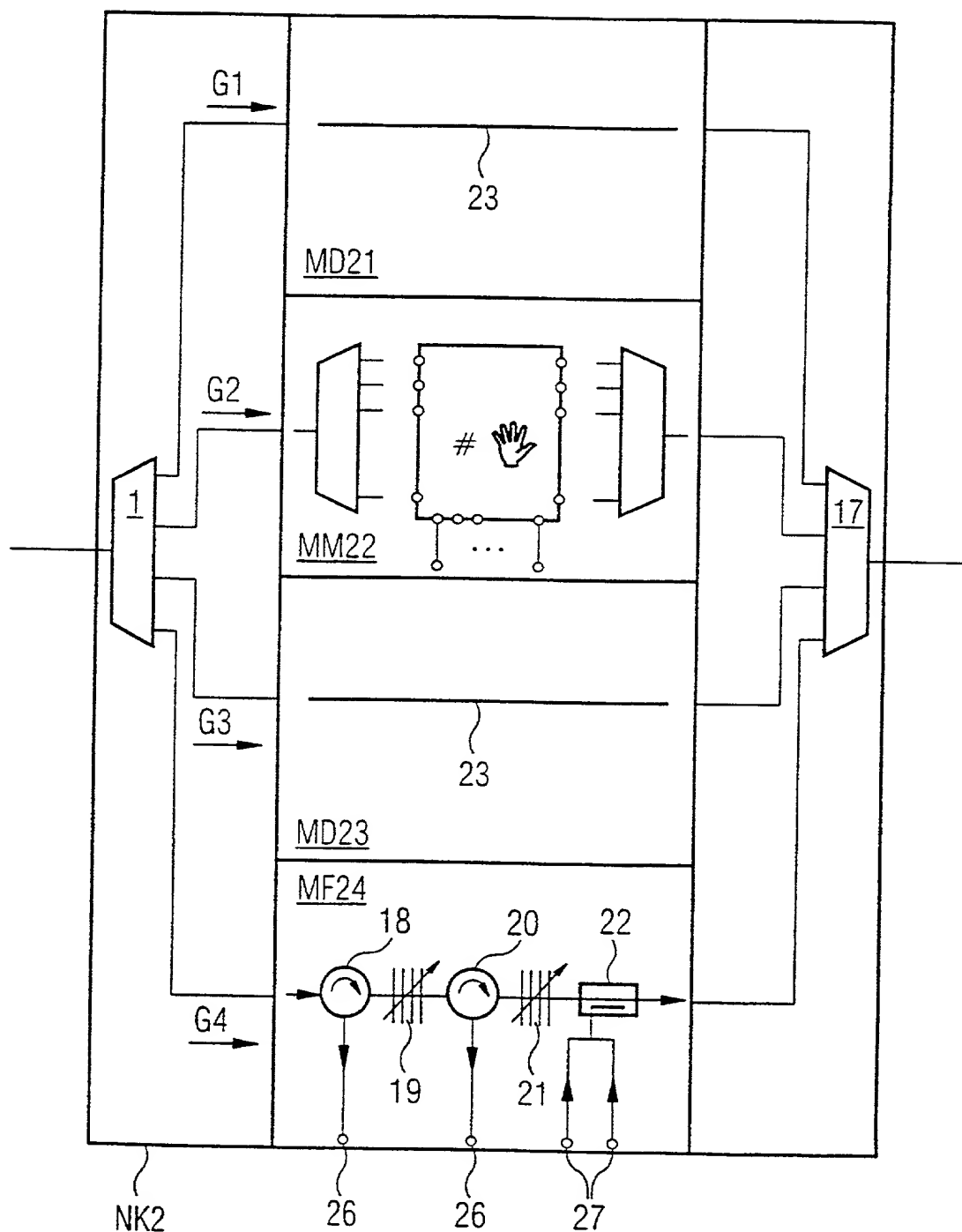


FIG 3



3/4

FIG 4



ERSATZBLATT (REGEL 26)

4/4

FIG 5

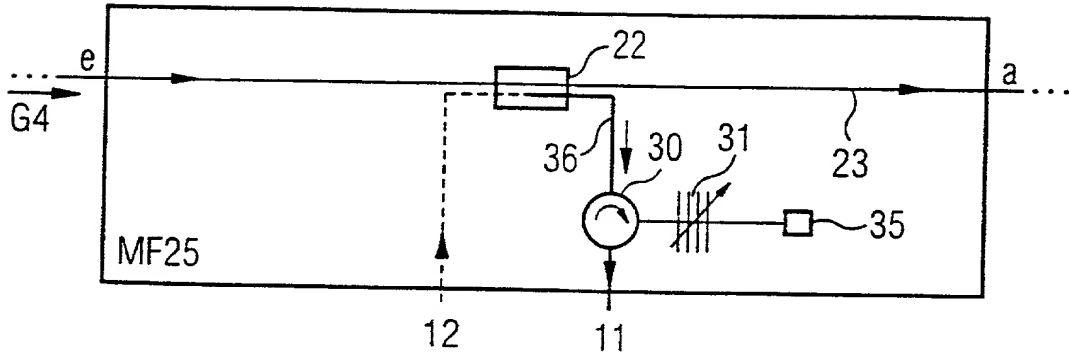


FIG 6

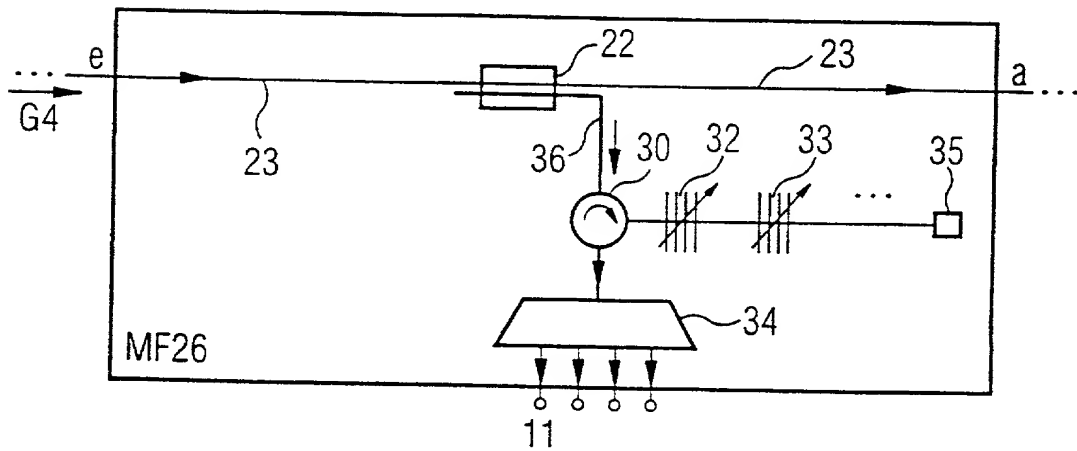
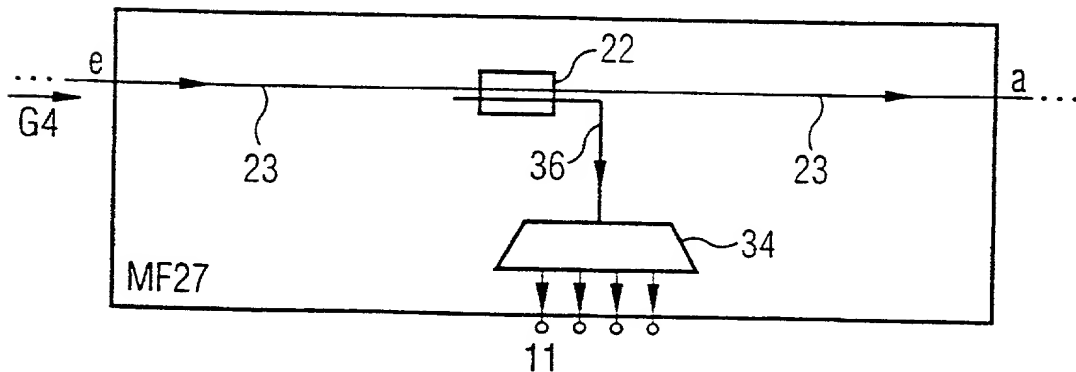


FIG 7



Declaration and Power of Attorney For Patent Application

Erklärung Für Patentanmeldungen Mit Vollmacht

German Language Declaration

Als nachstehend benannter Erfinder erkläre ich hiermit an Eides Statt:

dass mein Wohnsitz, meine Postanschrift, und meine Staatsangehörigkeit den im Nachstehenden nach meinem Namen aufgeführten Angaben entsprechen,

dass ich, nach bestem Wissen der ursprüngliche, erste und alleinige Erfinder (falls nachstehend nur ein Name angegeben ist) oder ein ursprünglicher, erster und Miterfinder (falls nachstehend mehrere Namen aufgeführt sind) des Gegenstandes bin, für den dieser Antrag gestellt wird und für den ein Patent beantragt wird für die Erfindung mit dem Titel:

Add-Drop-Multiplexereinrichtung und
optisches Wellenlängen-Multiplex-
Übertragungssystem
 deren Beschreibung

(zutreffendes ankreuzen)

☒ hier beigelegt ist.

☐ am _____ als

PCT internationale Anmeldung

PCT Anwendungsnummer _____

eingereicht wurde und am _____

abgeändert wurde (falls tatsächlich abgeändert).

Ich bestätige hiermit, dass ich den Inhalt der obigen Patentanmeldung einschliesslich der Ansprüche durchgesehen und verstanden habe, die eventuell durch einen Zusatzantrag wie oben erwähnt abgeändert wurde.

Ich erkenne meine Pflicht zur Offenbarung irgendwelcher Informationen, die für die Prüfung der vorliegenden Anmeldung in Einklang mit Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) von Wichtigkeit sind, an.

Ich beanspruche hiermit ausländische Prioritätsvorteile gemäss Abschnitt 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 119 aller unten angegebenen Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde, und habe auch alle Auslandsanmeldungen für ein Patent oder eine Erfindersurkunde nachstehend gekennzeichnet, die ein Anmeldedatum haben, das vor dem Anmeldedatum der Anmeldung liegt, für die Priorität beansprucht wird.

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

_____ the specification of which

(check one)

☐ is attached hereto.

☐ was filed on _____ as

PCT international application

PCT Application No. _____

and was amended on _____ (if applicable)

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations, §1.56(a).

I hereby claim foreign priority benefits under Title 35, United States Code, §119 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

German Language Declaration

Prior foreign applications
Priorität beansprucht

Priority Claimed

19906813.5 Germany

18. February 1999



(Number)
(Nummer)

(Country)
(Land)

(Day Month Year Filed)
(Tag Monat Jahr eingereicht)

Yes
Ja

No
Nein

(Number)
(Nummer)

(Country)
(Land)

(Day Month Year Filed)
(Tag Monat Jahr eingereicht)

Yes
Ja

No
Nein

(Number)
(Nummer)

(Country)
(Land)

(Day Month Year Filed)
(Tag Monat Jahr eingereicht)

Yes
Ja

No
Nein

Ich beanspruche hiermit gemäss Absatz 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 120, den Vorzug aller unten aufgeführten Anmeldungen und falls der Gegenstand aus jedem Anspruch dieser Anmeldung nicht in einer früheren amerikanischen Patentanmeldung laut dem ersten Paragraphen des Absatzes 35 der Zivilprozessordnung der Vereinigten Staaten, Paragraph 122 offenbart ist, erkenne ich gemäss Absatz 37, Bundesgesetzbuch, Paragraph 1.56(a) meine Pflicht zur Offenbarung von Informationen an, die zwischen dem Anmeldedatum der früheren Anmeldung und dem nationalen oder PCT internationalen Anmeldedatum dieser Anmeldung bekannt geworden sind.

I hereby claim the benefit under Title 35, United States Code, §120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, §122, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, §1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application.

(Application Serial No.)
(Anmeldeseriennummer)

(Filing Date)
(Anmeldedatum)

(Status)
(patentiert, anhängig,
aufgegeben)

(Status)
(patented, pending,
abandoned)

(Application Serial No.)
(Anmeldeseriennummer)

(Filing Date)
(Anmeldedatum)

(Status)
(patentiert, anhängig,
aufgeben)

(Status)
(patented, pending,
abandoned)

Ich erkläre hiermit, dass alle von mir in der vorliegenden Erklärung gemachten Angaben nach meinem besten Wissen und Gewissen der vollen Wahrheit entsprechen, und dass ich diese eidesstattliche Erklärung in Kenntnis dessen abgebe, dass wissentlich und vorsätzlich falsche Angaben gemäss Paragraph 1001, Absatz 18 der Zivilprozessordnung der Vereinigten Staaten von Amerika mit Geldstrafe belegt und/oder Gefängnis bestraft werden koennen, und dass derartig wissentlich und vorsätzlich falsche Angaben die Gültigkeit der vorliegenden Patentanmeldung oder eines darauf erteilten Patentes gefährden können.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

German Language Declaration

VERTRETUNGSVOLLMACHT: Als benannter Erfinder beauftrage ich hiermit den nachstehend benannten Patentanwalt (oder die nachstehend benannten Patentanwälte) und/oder Patent-Agenten mit der Verfolgung der vorliegenden Patentanmeldung sowie mit der Abwicklung aller damit verbundenen Geschäfte vor dem Patent- und Warenzeichenamt: (Name und Registrationsnummer anführen)

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (list name and registration number)

And I hereby appoint
Messrs. John D. Simpson (Registration No. 19,842), Lewis T. Steadman (17,074), William C. Stueber (16,453), P. Phillips Connor (19,259), Dennis A. Gross (24,410), Marvin Moody (16,549), Steven H. Noll (28,982), Brett A. Valiquet (27,841), Thomas I. Ross (29,275), Kevin W. Gwynn (29,927), Edward A. Lehmann (22,312), James D. Hobart (24,149), Robert M. Barrett (30,142), James Van Santen (16,584), J. Arthur Gross (13,615), Richard J. Schwarz (13,472), and Melvin A. Robinson (31,870), David R. Metzger (32,919), John R. Garrett (27,888) all members of the firm of Hill, Steadman & Simpson, A Professional Corporation.

Telefongespräche bitte richten an:
(Name und Telefonnummer)

Direct Telephone Calls to: (name and telephone number)

312/876-0200
Ext. _____

Postanschrift

Send Correspondence to:

HILL, STEADMAN & SIMPSON
A Professional Corporation
85th Floor Sears Tower, Chicago, Illinois 60606

Voller Name des einzigen oder ursprünglichen Erfinders:		Full name of sole or first inventor:	
STOLL, Detlef			
Unterschrift des Erfinders	Datum	Inventor's signature	Date
<i>[Signature]</i>	07 Feb '00		
Wohnsitz		Residence	
D-81377 München, Germany <i>DEX</i>			
Staatsangehörigkeit		Citizenship	
Bundesrepublik Deutschland			
Postanschrift		Post Office Address	
Hammersbacher Str. 23 a			
D-81377 München			
Bundesrepublik Deutschland			
Voller Name des zweiten Miterfinders (falls zutreffend):		Full name of second joint inventor, if any:	
LEISCHING, Patrick			
Unterschrift des Erfinders	Datum	Second Inventor's signature	Date
<i>[Signature]</i>	07.2.2000		
Wohnsitz		Residence	
D-80802 München, Germany <i>DEX</i>			
Staatsangehörigkeit		Citizenship	
Bundesrepublik Deutschland			
Postanschrift		Post Office Address	
Antonienstr. 7			
D-80802 München			
Bundesrepublik Deutschland			

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).

300

400

Patent and Trademark Office

Voller Name des dritten Miterfinders: BOCK, Harald		Full name of third joint inventor	
Unterschrift des Erfinders <i>Harald Bock</i>	Datum 7.2.2000	Inventor's signature	Date
Wohnsitz D-81479 München, Germany DEX		Residence	
Staatsangehörigkeit Bundesrepublik Deutschland		Citizenship	
Postanschrift Hofbrunnstr. 21		Post Office Address	
D-81479 München			
Bundesrepublik Deutschland			
Voller Name des vierten Miterfinders (falls zutreffend): JÄGER, Hubert		Full name of fourth joint inventor, if any:	
Unterschrift des Erfinders <i>Hubert Jäger</i>	Datum 7.2.00	Inventor's signature	Date
Wohnsitz D-82049 Pullach, Germany DEX		Residence	
Staatsangehörigkeit Bundesrepublik Deutschland		Citizenship	
Postanschrift Karl-Schröder-Str. 10		Post Office Address	
D-82049 Pullach			
Bundesrepublik Deutschland			
Voller Name des fünften Miterfinders (falls zutreffend):		Full name of fifth joint inventor, if any:	
Unterschrift des Erfinders	Datum	Inventor's signature	Date
Wohnsitz		Residence	
Staatsangehörigkeit		Citizenship	
Postanschrift		Post Office Address	
Voller Name des sechsten Miterfinders (falls zutreffend):		Full name of sixth joint inventor, if any:	
Unterschrift des Erfinders	Datum	Inventor's signature	Date
Wohnsitz		Residence	
Staatsangehörigkeit		Citizenship	
Postanschrift		Post Office Address	

(Bitte entsprechende Informationen und Unterschriften im Falle von dritten und weiteren Miterfindern angeben).

(Supply similar information and signature for third and subsequent joint inventors).